Activity 2 Igneous Rocks and the Geologic History of Your Community

Goals

In this activity you will:

- Identify several igneous rocks using a rock chart.
- Describe how the two main types of igneous rocks form.
- Understand that igneous rocks are classified based on how they form.
- Use a geologic map and legend to search for evidence of past igneous rock formation.
- Understand that classification helps scientists organize the natural world into smaller, workable components.

Think about It

Igneous rocks cool and crystallize from a molten rock (magma).

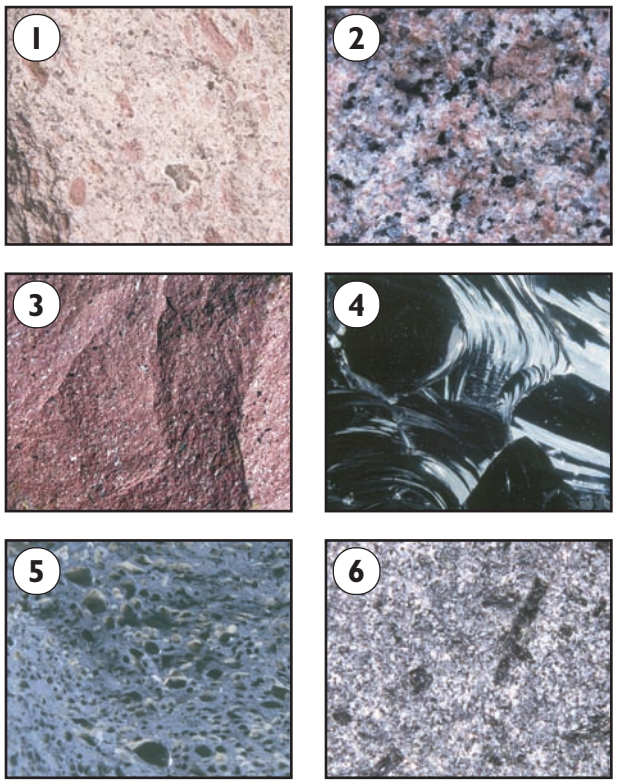
- How are these rocks similar to, and different from, the sedimentary rocks that you have seen?

What do you think? Record your ideas about this question in your *EarthComm* notebook. Include a quick sketch. Be prepared to discuss your response with your small group and the class.

Investigate

Part A: Working with Igneous Rocks

1. Examine the photographs of the igneous rocks shown, or a set of igneous rock samples that you are provided.



   a) List some ways you can divide these igneous rocks into groups or categories.

2. Separate the samples into the categories you have decided to use. You might sort them in more than one way.

   a) List the rocks that you place in each category.

   b) Describe the difficulties you experienced trying to categorize them in each way you used.

3. Compare your classification system with the categories used by another group.

   a) Add any categories to your list they used that you had not thought about.

4. Refer to the chart of The Classification of Igneous Rocks on page U20.

   a) Use the chart to name each igneous rock sample.

   b) How do geologists classify igneous rocks?

   c) Describe the similarities and differences between your classification scheme and that of geologists.

   d) What is an advantage to classifying rocks into different groups?

5. Magma cools faster at the Earth's surface (for example, after a volcanic eruption) than it does when it cools below the ground. The faster the cooling and crystallization, the smaller the crystals. Observe the rock samples (or photographs) and the chart of igneous rocks to answer the following questions:

   a) Does rhyolite form at or below the Earth's surface? Explain.

   b) Does gabbro form at or below the Earth's surface? Explain.

Part B: Evidence of Igneous Rocks in Your Community

1. A geologic map, such as one shown in Activity 1, page U7, shows the rocks and sediments at the Earth's surface. Each color or symbol on the map stands for a type and/or age of rock. Geologic maps have a legend. Colors and symbols in the legend explain the types and/or ages of rock shown on the map. Examine the geologic map of your community or region.

   a) Are there any igneous rocks described in the legend? If so, write down a list of the rock type, locations, and ages (in millions of years) if possible. Make a data table to record your observations. If there are numerous igneous rocks in your community, limit your data table to about five different examples.

   b) What are the most common igneous rocks in your area?

   c) Many igneous rocks are very resistant to weathering, and thus erode more slowly than other kinds of rocks. When igneous rock is surrounded by softer rock, a distinct elevated landform may develop. Locate an elevated or prominent landform in your community or region (choose a familiar hill, mountain, rock exposure, or cliff). Is the landform made of igneous rock?

Reflecting on the Activity and the Challenge

Learning how to classify rocks by their physical and/or chemical properties will help you use rock charts to identify the rock specimens. Being able to identify igneous rocks and understanding how they form will help you determine the geology of the area as you work on your Chapter Challenge.

Digging Deeper

IGNEOUS ROCKS

The Nature of Igneous Rocks

All igneous rocks are made of interlocking crystals of minerals that cool and crystallize out of **magma** (molten rock). The interlocking nature of the crystals makes igneous rocks very resistant to **physical weathering** and **erosion**. **Minerals** are the building blocks of igneous rocks (and all other rocks as well). Minerals are compounds of usually several chemical elements. Each mineral has a particular chemical composition and crystal structure. Each mineral has a chemical formula, which expresses the proportions of the various chemical elements in its composition. Although there are literally thousands of kinds of minerals in the Earth's crust, only six kinds of minerals are common in igneous rocks (fortunately for beginning students of igneous rocks!). These are quartz, feldspars, micas, pyroxenes, amphiboles, and olivines. These are all called **silicate** minerals, because their basic structure consists of very tightly bonded units consisting of silicon and oxygen (called silica) that are bonded less strongly to various other atoms. Of the six kinds, all but quartz are listed in the plural form (-s), because the details of their compositions can vary widely even though the basic nature of the mineral is the same. For example, there are two kinds of feldspars (plagioclase and potassium feldspar), with slightly different structures and very different chemical compositions. And there are two kinds of micas (muscovite and biotite), again with slightly different structures but very different chemical compositions.

Magma, Lava, and Igneous Rock

Igneous rocks are formed from cooling of magma. Suppose that you could drill a hole very deep into the Earth. You would find that the Earth's temperature initially rises by about 30°C with every kilometer of depth. This rate of increase slows down at deeper depths. At a depth of 100 to 350 km, the temperature is high enough for large volumes of rock to melt and form magma at certain times and places. Nearly all substances expand when they are heated. When rock is melted into magma, its volume increases by about 10%. This makes the magma less dense than the surrounding rock. Like a hot-air balloon that rises through less dense surrounding air, magma rises toward the Earth's surface. (See *Figure 1*.) Some magmas cool and solidify into igneous rock before they reach the surface. The igneous rock that forms in that way is called **intrusive igneous rock** (because the magma "intrudes" into solid rock that was already there). In some places, magma reaches the surface before it solidifies into igneous rock.

Geo Words

igneous rock: a rock that solidified from molten or partly molten material, i.e., from magma.

magma: naturally occurring molten rock material, generated within the Earth, from which igneous rocks have been derived through solidification and related processes.

physical weathering: the processes of weathering by which rock is broken down by physical forces or processes, including gravity, water, ice, wind, or human actions at or near the Earth's surface.

mineral: a naturally occurring inorganic, solid material that consists of atoms and/or molecules that are arranged in a regular pattern and have characteristic chemical composition, crystal form, and physical properties.

erosion: the wearing away of soil or rock by weathering, mass wasting (downhill movement of material under the influence of gravity), and the action of streams, glaciers, waves, wind, and underground water.

silicate: a compound whose basic structure consists of very tightly bonded units consisting of silicon and oxygen (called silica) that are bonded less strongly to various other atoms.

intrusive igneous rock: igneous rock formed at considerable depth by the crystallization of magma.

Geo Words

lava: magma that reaches the Earth's surface.

extrusive igneous rock: igneous rock that has erupted onto the surface of the Earth.

Magma that reaches the surface is called **lava**. Rock that is formed when lava cools is called **extrusive igneous rock** (because the lava is "extruded" onto the Earth's surface, like toothpaste from a tube). As you will see, the appearance of an igneous rock reveals whether or not it formed below or at the Earth's surface.

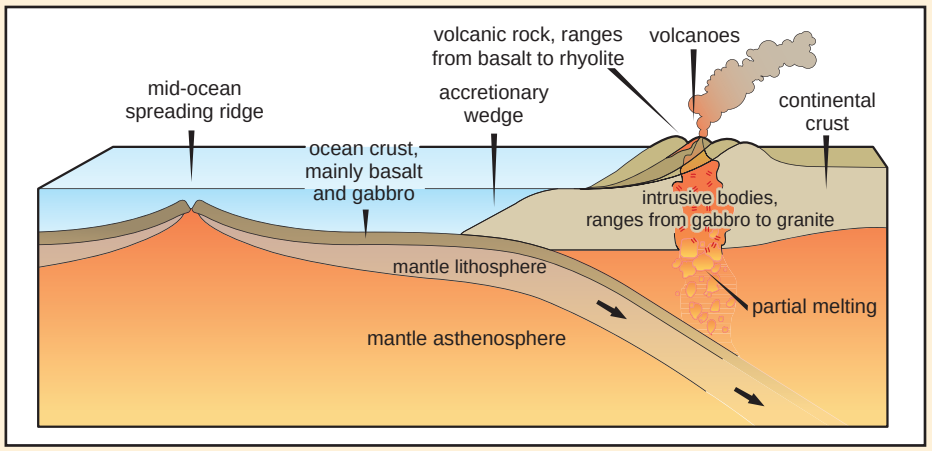


Figure 1 Cross section of mantle and crust.

Classifying Igneous Rocks: Texture

The crystal size of an igneous rock depends very strongly on how fast the magma cools. When magma cools very slowly, only a small number of crystals are formed in a given volume of the magma, but they have plenty of time to grow to be large. The resulting igneous rock is coarse-grained, with mineral grains that are usually several millimeters, or even a few centimeters, in size, as shown in *Figure 2*. On the other hand, when a magma is extruded at the Earth's surface and cools very rapidly, a large number of crystals are formed in a given volume of the magma. However, there is not enough time for them to grow to be large. The resulting igneous rock is very fine-grained with minerals grains that are usually too small to be seen without a magnifying glass. If the lava cools even more quickly, a glassy textured rock called obsidian can form. Obsidian forms when magma cooled so quickly that no crystals have time to form.

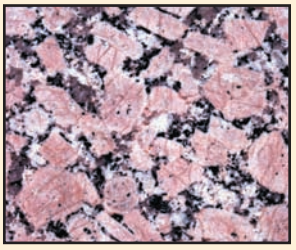


Figure 2 Granite with coarse-grained texture.

Figure 3 Granite with medium-grained texture.

Classifying Igneous Rocks: Chemical and Mineral Composition

The color of an igneous rock is determined mainly by the chemical composition, and therefore the mineral composition, of the rock. Recall the common igneous rock-forming minerals. Quartz, potassium feldspar, and muscovite mica are light in color. Igneous rocks with high percentages of these minerals tend to be light in color. They are the most common minerals in igneous rocks of the continental crust. Pyroxenes, amphiboles, plagioclase feldspar, biotite mica, and olivines are darker in color. Igneous rocks with high percentages of these minerals tend to be dark in color.

Igneous rocks that consist mostly of minerals like quartz, potassium feldspar, and muscovite mica, which are rich in silica (silicon and oxygen) but poor in iron and magnesium, are lighter in color, because these minerals are usually white, light gray, or pink. These rock types, whether intrusive or extrusive, are associated with places where **lithospheric plates** are moving together and magma is formed. Magmas rich in silica do not flow very easily and usually cool before they reach the Earth's surface to form granite. Granites found at the Earth's surface today formed below the surface long ago and have been exposed by uplift and erosion. If the same magma reaches the surface, it cools quickly to form an extrusive igneous rock called rhyolite.

Igneous rocks that contain minerals that are rich in iron and magnesium (olivines, amphiboles, pyroxenes, and biotite mica) are dark in color, typically black to dark green. One extrusive igneous rock of this kind, basalt, is the most common rock on the Earth's surface, because it is the major rock of the oceanic crust. Basalt is formed where lithospheric plates are spreading apart or where magma is rising through a mantle hot spot. These rocks are common in the Hawaiian Islands and Iceland. Gabbro is an intrusive igneous rock that contains minerals rich in iron and magnesium. It is the coarse-grained counterpart of basalt. It is common deep in the oceanic crust.

Some igneous rocks are intermediate in chemical composition. These rocks are made of a mixed content of minerals that contain iron and magnesium. These rocks are therefore also intermediate in color. Andesite, an extrusive rock, and diorite, the corresponding intrusive rock, are examples. Andesite (named for the Andes Mountains, where it is abundant) and diorite often form where an oceanic lithsopheric plate is being subducted beneath a continental lithospheric plate. Water rising up into the mantle from the down-going plate causes some of the mantle rock to melt. As the magma rises up through the continental plate, it melts some of the continental rocks, causing it to have an intermediate composition.

Geo Words

lithospheric plate: a rigid, thin segment of the outermost layer of the Earth, consisting of the Earth's crust and part of the upper mantle. The plate can be assumed to move horizontally and adjoins other plates.

Classification of Igneous Rocks					
Color		**Light**	**Intermediate**	**Dark**	**Dark**
Mineral composition		quartz (≥5%) plagioclase feldspar potassium feldspar iron-magnesium rich minerals (≤15%)	quartz (<5%) plagioclase feldspar potassium feldspar iron-magnesium rich minerals (15-40%)	no quartz plagioclase feldspar (~50%) no potassium feldspar iron-magnesium rich minerals (~40%)	nearly 100% iron magnesium rich minerals
Texture	Crystals >10 mm	granite pegmatite	diorite pegmatite	gabbro pegmatite	
	Crystals 1–10 mm	granite	diorite	gabbro	peridotite
	Crystals <1 mm	rhyolite	andesite	basalt	
	Glassy	obsidian		obsidian	
	Frothy	pumice		scoria	

Explosive Volcanic Eruptions

Figure 4 Pumice sample from Mt. St. Helens.

Some magmas, especially magmas that are silica-rich, have a high content of dissolved gases, like water vapor and carbon dioxide. When these magmas rise up to near the Earth's surface, the dissolved gases tend to bubble out of the magma, because the pressure is so much lower than deep in the Earth. Sometimes the pressure is released suddenly by a violent explosive volcanic eruption, as happened at Mt. St. Helens in the Pacific Northwest in 1980. The products of such an eruption are pieces of mineral grains and broken igneous rock, called volcanic ash. In one sense, the rock formed from volcanic ash is a sedimentary rock because it is formed by the deposition of material. However, because it came directly from a volcano it is usually considered to be an igneous rock. Pumice is a volcanic rock that consists mainly of bubble holes, with only thin walls between the holes. Because of its very low density, pumice floats on water!

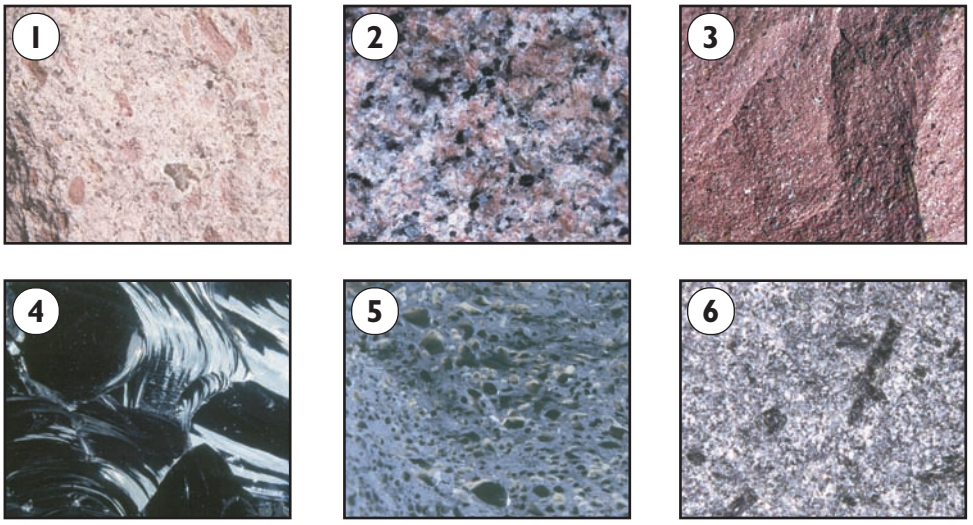
Check Your Understanding

1. In your own words, describe the difference between an intrusive igneous rock and an extrusive igneous rock.
2. How do the two main types of igneous rocks form?
3. Explain the relationship between the mineral composition of an igneous rock and the color of the rock.
4. Explain how the texture of an igneous rock reveals how the rock formed.

Understanding and Applying What You Have Learned

1. Use the photographs of the rocks shown, or obtain several new samples of igneous rocks. Use the rock chart to answer the following questions:
   a) Is the rock light, intermediate, or dark in color?
   b) Is the rock glassy, or does it have fine crystals, or coarse crystals?
   c) Is the rock intrusive or extrusive?
   d) Name each rock.

2. Examine the geologic map of your community and the list of igneous rocks that you generated in Part B of the investigation.
   a) Did the igneous rocks in your community or area form underground or at the Earth's surface? Explain.
   b) Focus in on the area that you have selected for your chapter report. Describe any evidence of igneous rocks.



Preparing for the Chapter Challenge

Using the information you have gathered about the igneous rocks in your community or state, make inferences about past plate motion that affected your community or area. Name the igneous rock types that helped you make your decisions.

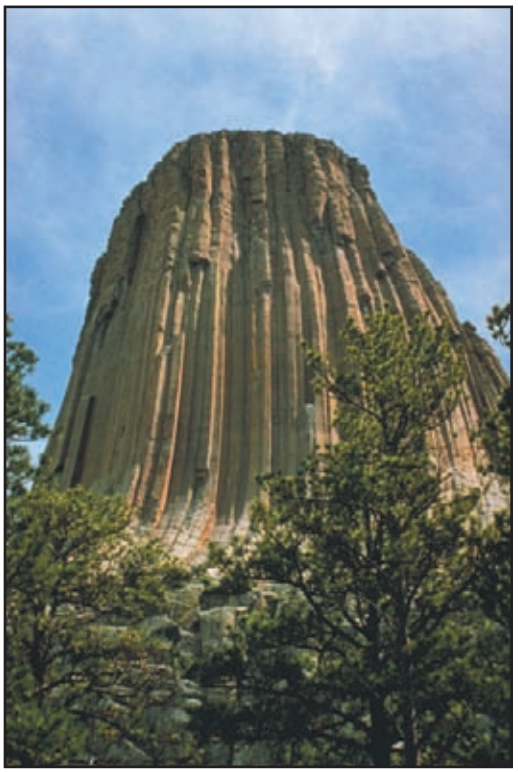
Inquiring Further

1. **Igneous rocks and famous landscapes**

   Investigate one of the following:

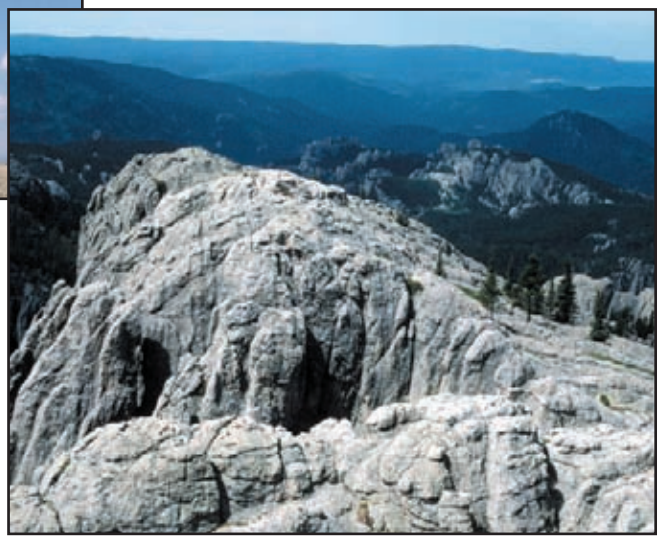
   - Ship Rock, New Mexico
   - Sierra Nevada Batholith, Yosemite National Park, California
   - Devil's Postpile National Monument, California

   From what igneous rock is the famous landform made? What does the landform and its rock composition tell you about the geological history of that place?



Devil's Postpile National Monument, California.

Ship Rock, New Mexico.



Sierra Nevada Batholith, Yosemite National Park, California.